THE PTERYLOGRAPHY OF CERTAIN AMERICAN GOATSUCKERS AND OWLS.

By Hubert Lyman Clark.

A recent examination of a number of Caprimulgi and Striges for the purpose of studying their pterylographical characteristics has proved of such interest that the results seem worthy of publication, although the work is necessarily only preliminary. In the carrying on of these studies I have been placed under great obligation to Dr. R. W. Shufeldt and Mr. F. A. Lucas, of Washington, for many helpful suggestions, and to the National Museum for much of the material. For the rest of the material I am indebted to Mr. F. A. Ward, of Rochester, and especially to Mr. Frank B. Armstrong, of Brownsville, Tex., who has given me invaluable assistance. I am also under great obligations to Dr. W. J. Holland, of Pittsburg, for the use of his valuable scientific library, without which I should have been placed at great disadvantage.

All of the specimens examined have been birds in the flesh, either fresh or alcoholic, as the use of skins for the study of pterylography seems to be of questionable value. Owing to the fact that Striges have eleven primaries while Caprimulgi have only ten, I have adopted the somewhat radical change advocated by Wray* of numbering the primaries from the wrist outward instead of from the tip of the wing inward, as is usual. Although I do not consider the plan wholly free from objections, it has been necessary to do this to avoid inextricable confusion in comparing the primary formulæ in the two groups, for the real first primary of the owls is wanting in the Caprimulgine wing. For the same reason the central pair of tail feathers is designated as number one and the outer pair five or six, as the case may be.

As the four genera of North American Caprimulgi have all been examined, I give first as complete a review of the pterylosis of this group as the material at hand will warrant, with particular reference to each genus. After this is given an account of such owls as have been obtainable, and this is followed by a comparison of the pterylography of the two groups and the conclusions to which I have been led. The work is, as already stated, only preliminary, and, of course, can only be completed by a study of all the important species of both

* Proc. Zool. Soc. London, 1887, p. 343.

groups, but it is hoped that the present article may not only serve as an introduction to such a work, but may also arouse more interest in the study of comparative pterylography.

CAPRIMULGI.

In Nitzsch's "System der Pterylographie" there is given a fairly complete account of the pterylosis of *Caprimulgus europæus* and further remarks on *C. longipennis*, *forcipatus*, and *spalurus*, *Ægotheles novæ hollandiæ*, *Podargus gigas*, and *Nyctornis æthereus*, but apparently the celebrated German had not examined our North American species. Dr. Shufeldt has carefully described the pteryloses of *Antrostomus* and *Chordeiles* in his memoir on the Macrochires,* and the former is figured. So far as I know these are the only important papers which have yet appeared bearing directly on the pterylography of the group, unless we include *Steatornis*, which has been examined and the pterylosis figured by Garrod,† although it is not improbable that others may have escaped my search.

The Caprimulgi are remarkable for the variations shown in the pteryloses of the different genera, but the plan is similar in all the North American species and may be briefly summed up as follows: The whole head is fully covered with feathers, which are, however, arranged in more or less complete and often parallel longitudinal rows, forming on the forehead and crown definite patterns, each genus having its own peculiar arrangement. From the head there extends backward dorsally the upper cervical tract which, dividing between the shoulders into two strong forks, extends to the end of the shoulder blades. The dorsal tract, which begins immediately behind this fork, shows great variation in its distinctness and extent, but is usually more or less forked at first and then, uniting into a single tract, runs backward to the root of the tail. Anteriorly it may unite its two branches with those of the cervical tract, thus inclosing a diamond-shaped spinal space, as best shown in *Phalænoptilus*, or it may spread out more decidedly toward the sides and even send forward a few feathers almost to the humeral tracts, as is well shown in *Chordeiles virginianus*. The humeral tracts are strongly defined, and the upper surface of the wing is very completely feathered, except for an evident apterium at the outer end of the humerus. The parapterum is not always very evident, but usually connects the humeral tract with the feathers of the forearm, of which there are seven or eight more or less complete rows, the lower three or four being the secondary coverts, while there are also two very strong rows of primary coverts. Directly at the knee-joint is a prominent femoral tract, which, after crossing the tibia diagonally, extends part way along the posterior edge of the femur, although it never reaches as far as the dorsal tract. The pterylosis beneath is more uniform. The

* Jour. Linnean Soc., xx, pp. 299–394.

† Proc. Zool. Soc., 1873, p. 526.

lower cervical tract forks at about the middle of the neck and each branch extends down over the side of the breast, where it is very broad and strong, and then (as it enters on the surface of the abdomen, or a little before) suddenly contracts to a strip only two rows broad, which curves inward and ends a little in front of the anus. The hypopterum is generally very evident and connects the sternal tract with the incomplete fourth row of under wing coverts. The lower surface of the wing is very slightly feathered, but there are two complete rows of primary and three of secondary coverts and an incomplete fourth row of the latter. The four genera agree also in the following details:

Aftershafts present but weak. True down wanting. Oil gland not tufted. Primaries, 10. Rectrices, 10. Alula feathers, 3. Secondaries, 12 or 13, but the wing is aquincubital.

The larger wing and tail feathers are all peculiar in the length of the quill (*calamus*) and the corresponding shortening of the shaft (*rhacis*) which ends with the vexillæ. The four genera fall naturally into two groups, as follows:

I. Secondaries, 12; tail not forked, the central pair of rectrices longest; rictal bristles very prominent; infra-mandibular region sparsely feathered; no inner branch or tooth on the lower cervical tract.

A. Only 8 complete longitudinal rows of feathers on the crown. Tarsus not feathered at all ..... PHALÆNOPTILUS.

B. Eight complete rows, but tarsus feathered halfway down in front. ANTROSTOMUS.

C. Ten complete rows and tarsus not feathered ..... NYCTIDROMUS.

II. Secondaries, 13; tail forked, central pair of rectrices shortest; rictal bristles not evident; inframandibular region well feathered; lower cervical tract with a prominent inner tooth.

A. Ten complete rows on crown. Tarsus feathered in front ..... CHORDEILES.

Genus PHALÆNOPTILUS.

Of this genus I have only had the opportunity to examine one specimen, but as that was in good condition, it probably illustrates correctly the pterylosis of the genus. As the primaries had been cut off, the formula for their comparative lengths can not be given, but there were 12 secondaries. On each side of the head, along the edge of the rictus, there is a single row of long, stout, bristle-like feathers. Above this is a second row of smaller contour feathers and above this a third incomplete row of the same. From the base of the culmen (fig. 1) there run backward on each side two rows of contour feathers, so near together as to almost make a single row. For a short distance these double rows are about parallel, and then curving inward they unite for a short distance into a band three rows broad. On the crown they separate once more into four distinct rows, which, although somewhat curved, are almost parallel* for some distance, but unite again at the commencement of the cervical tract. Another row begins on each

* Used in the sense of being equidistant at all points.

side just behind the nostrils and runs backward into the cervical tract almost parallel to those first described. The fourth complete row on each side commences under the eye, near the angle of the mouth, and after running forward a little way curves up and back and runs parallel to the others into the cervical tract. There is another incomplete row on each side, which begins about the middle of the upper eyelid and runs down the back of the head behind the ear, but does not seem to join in the cervical tract. The rows are closer together than in any of the other genera and curve as shown in fig. 1. The upper cervical tract is quite broad and is clearly and widely forked at the end. The dorsal

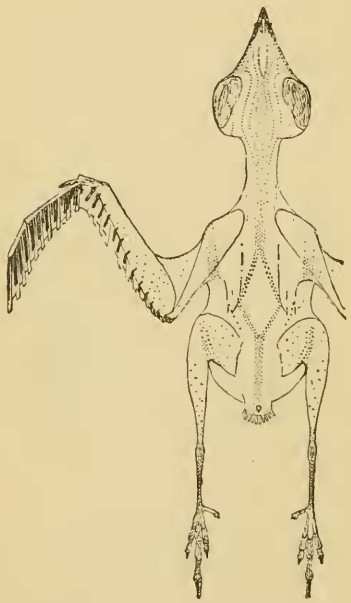

Fig. 1.

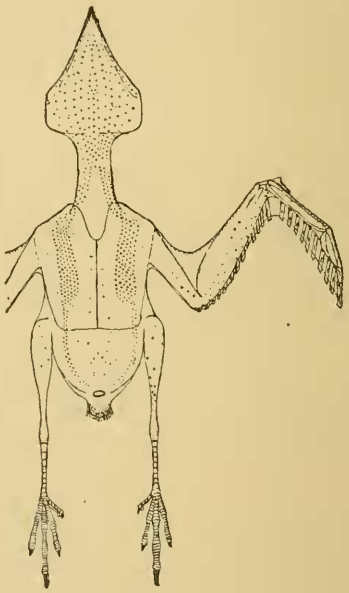

Fig. 2.

PTERYLOSIS OF PHALÆNOPTILUS NUTTALLI.

tract extends forward from the oil gland, in a rather narrow band which is forked in front and unites plainly with the cervical tract, thus inclosing a diamond-shaped spinal space. There are on each side of this fork a few scattered contour feathers, but they are not very evident. The femoral tract is clearly defined, but is not peculiar in any way, though on the femur between it and the dorsal tract there are many scattered contour feathers. There are also a few such feathers on the tibia, but there are none on the tarsus. The humeral tracts are strong and extending clear across the shoulders unite with the ventral tracts. The feathers on the chin and throat (fig. 2) are widely separated and are arranged in more or less longitudinal rows which converge in front to

unite at the base of the gonys. The lower cervical tract is broad and divides near the middle of the neck. The ventral tract contracts on the breast some distance before reaching the posterior edge of the sternum and ends a little in front of the anus. There are scattered contour feathers on the belly and on the sides of the breast anterior to the hypopterum.

Specimen examined.

No.	Name.	Collection.
1	Phalænoptilus nuttalli	U. S. National Museum.

Genus ANTROSTOMUS.

In general, this genus seems to agree very well with *Phalænoptilus*. The ten primaries give the following formula in comparative lengths: 8=9, 7=10, 6, 5, 4, 3, 2, 1, and there are 12 secondaries. The pattern

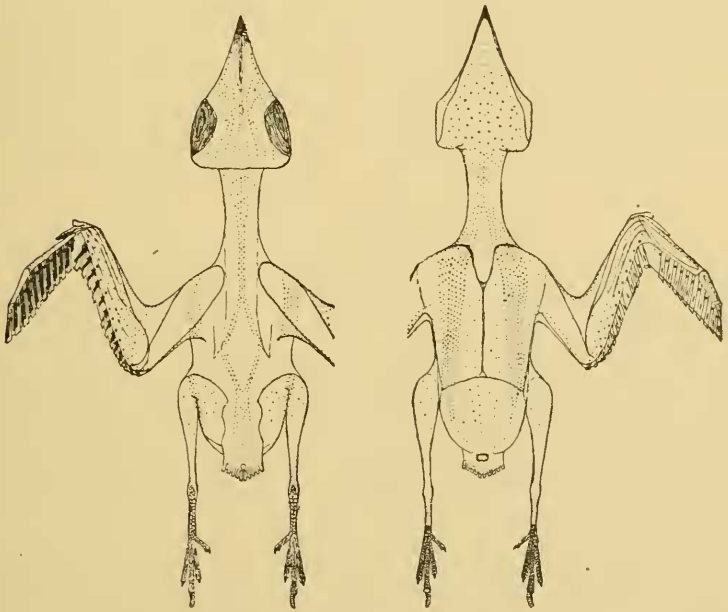

Fig. 3. Fig. 4.

PTERYLOSIS OF ANTROSTOMUS VOCIFERUS.

of the head-feathering (fig. 3) differs from the preceding genus in the absence of the third row along the rictus; in the greater curvature and wider separation of the rows and in a few other minor details easily seen on an examination of the plates. The upper cervical tract is broad at the start but becomes rapidly very narrow, while the rest of the upper

surface agrees with *Phalænoptilus*, although the dorsal tract is much broader, and there appear to be no scattered contour feathers on the back. Ventrally *Antrostomus* differs from the "Poor-wills" in a much greater sparseness of feathers on the chin (fig. 4) and in the continued breadth of the sternal tracts, which become narrower only as they enter on the surface of the abdomen. The feathering of the tibia does not end at the joint, but extends down on the tarsus in front, more than half way to the toes.

Specimens examined.

No.	Name.	Collection.	Condition.
1	Antrostomus vociferus	U. S. National Museum	Alcoholic.
2	do	Brownsville, Tex	Fresh.

It will at once be seen from the above description and figures that my observations on the pterylosis of this genus differ radically from those of Dr. Shufeldt.* In regard to this difference, Dr. Shufeldt assures me that he has compared his figure, since its publication, with other specimens and has found no changes necessary. He has, however, very kindly permitted me to examine his original drawings, and it is only fair to say that they do not differ so much from mine as do the figures in the plate. The latter seems to have been very carelessly executed, and so it is desirable to have a more accurate figure, which I hope is to be found above.

Genus NYCTIDROMUS.

In this genus the wing is very much like *Antrostomus*, as there are twelve secondaries, and the ten primaries give the following formula: 8, 9, 7, 10, 6, 5, 4, 3, 2, 1.

On the head (fig. 5) we find an arrangement of the rows quite different from the other three genera. There is the usual double row running from the foot of the culmen over the middle of the head, back to the cervical tract. Beside this and parallel to it are two single rows some distance from it and from each other. There is then a fifth complete row, running from the angle of the mouth beneath the eye, forward, then up and back over the upper eyelid, and finally into the cervical tract with the other four. From the inner side of this row a branch runs forward for some distance along the superior edge of the eye cavity. The row of rictal bristles is prominent, and there are a number of contour feathers, filling the space between it and the fourth longitudinal row. The upper cervical tract is very narrow, while the dorsal tract is rather broad. The spinal space is not very clearly defined, and there are several rows of strong contour feathers (with weaker ones scattered about) running at almost right angles to the dorsal tract, extending out from its anterior end. The femoral tracts are unusually well developed, and the tibiæ are feathered very

* Journal of the Linnean Society, xx, p. 299.

sparsely, but the tarsus is wholly bare. The humeral tract shows the remarkable peculiarity of not reaching entirely across the shoulder, but becomes almost obliterated at its anterior end. This was clearly shown in all the specimens examined. In the infra mandibular region the feathering is even more scattered than in *Antrostomus*, so as to

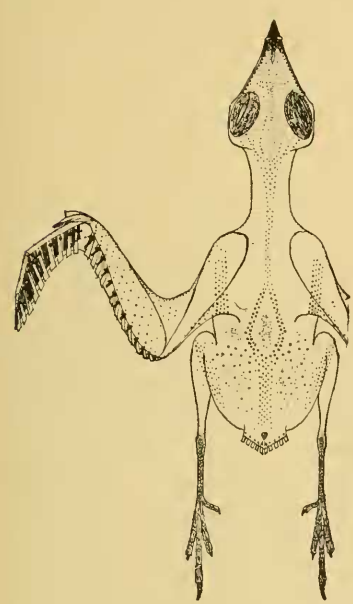

Fig. 5.

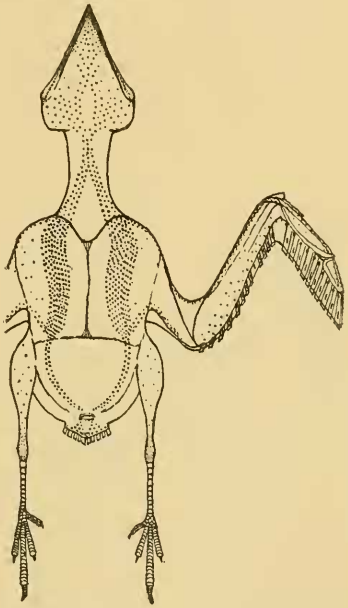

Fig. 6.

PTERYLOSIS OF NYCTIDROMUS ALBICOLLIS MERRILLI.

leave two very distinct and complete apteria (one on either side) and a less evident one in the center. The lower cervical tract (fig. 6) is very narrow and is deeply forked. The parapterum is not very strong, and in one specimen the hypopterum nearly failed altogether. In all other respects, however, it seems to agree with *Phalænoptilus*.

Specimens examined.

No.	Name.	Collection.	Condition.
1	Nyctidromus albicollis	U. S. Nat. Mus	Alcoholic.
2	Nyctidromus albicollis merrilli	Brownsville, Tex	Fresh.
3	do	do	Do.
4	do	do	Do.
5	do	do	Do.
6	do	do	Do.
7	do	do	Do.

Genus CHORDEILES.

In all of the specimens examined the primaries had been cut so that their formula can not be given, but there were 13 secondaries. On the head we see that the rictal bristles are so insignificant as to leave in

the plucked bird very little trace of their presence. There is on each side of the crown the usual double row of feathers running backward from culmen to cervical tract, and beside this, but at some distance from it, two widely separated parallel longitudinal rows. A fifth row runs across the extreme upper part of the eyelid with an outer branch down to the eyelid proper. The upper cervical tract is very broad in *C. virginianus* (fig. 7), but in *C. texensis* it is as narrow as in *Antrostomus*. In *C. virginianus* the fork of the cervical tract is very strong, but that of the dorsal tract is very indistinct, while from each side of the latter there

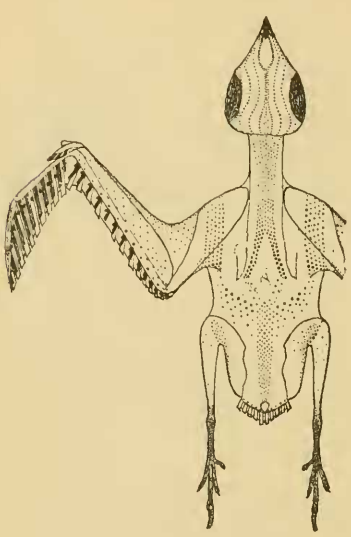

Fig. 7.

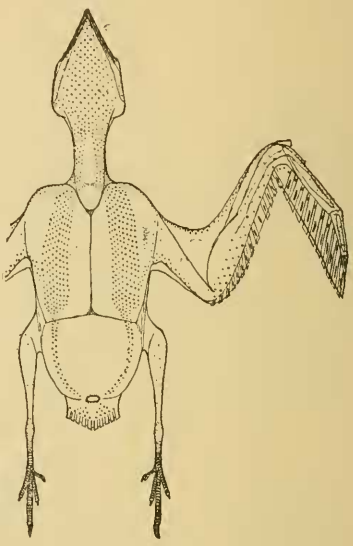

Fig. 8.

PTERYLOSIS OF CHORDEILES VIRGINIANUS.

extends a broad tract out and up over the back so as to connect very slightly with the broad humerals. In *C. texensis* the dorsal tract is much like *Antrostomus*, and there are no traces of the peculiar tracts, just described, on the sides of the back. In both species of *Chordeiles*, however, the femoral tracts are normal and the feet are feathered half-way down on the tarsus in front. On the lower surface (fig. 8) the two species agree with *Phalænoptilus*, except that the infra-mandibular region is very well feathered and the lower cervical tract, dividing very far up on the throat, bears on its inner edge, close by the furcula, a very noticeable branch or tooth, while the sternal tracts are remarkably broad and strong.

Specimens examined.

No.	Name.	Collection.	Condition.
1	Chordeiles virginianus	U. S. Nat. Mus	Alcoholic.
2	Chordeiles virginianus henryi	do	Do.
3	Chordeiles texensis	do	Do.

In regard to the differences in the dorsal tract as above given between *C. virginianus* and *C. texensis*, it is probable that an examination of fresh material, which it was impossible for me to obtain, will show that they are not so great as I have indicated. Indeed, it is likely that good specimens of *C. texensis* will show dorsal tracts similar to *C. virginianus*, as Dr. Shufeldt found them so in the specimens which he examined.*

STRIGES.

In his System des Pterylographie, Nitzsch has given an account of the pterylography of some 21 species of owls, of which at least five are American, namely: *Strix virginiana* (*Bubo virginianus*), *S. brachyotus* (*Asio accipitrinus*), *S. asio* (*Megascops asio*), *S. nyctea* (*Nyctea nyctea*), and *S. cunicularia* (*Speotyto cunicularia*). Besides these, *S. lapponica* is closely allied to our *Scotiaptex cinerea* and *Hybris flammea* is represented in our *Strix pratincola*. Aside from Nitzsch's work the only contribution to the pterylography of the owls which I have found is contained in some "Notes on the Anatomy of Speotyto cunicularia hypogæa" by Dr. Shufeldt,† in which is given a very complete and accurate account of the pterylosis of the burrowing owl; important differences between that form and the other owls being pointed out. As a rule, however, it may be safely said that the owls show a striking uniformity in the arrangement of the feathers, of which the general plan is as follows: The head is more or less fully feathered above, and especially densely in front. The upper cervical tract usually commences broad, but rapidly becomes narrow, and forks between the shoulders more or less deeply. The dorsal tract is very incomplete anteriorly and is only indistinctly connected with the cervical forks, but posteriorly it becomes a strong single band, which forks behind so as to more or less surround the oil gland. The humeral tracts are strong and usually broad and the parapterum is very evident. There are two complete rows of primary coverts, and on the forearm there are seven or eight rows of feathers, of which the lower three or four are true secondary coverts. The femoral tract is very strong and evident, running obliquely across the upper end of the tibia from the knee, along on the posterior edge of the femur. The tibia and tarsus are usually very completely covered with feathers, and often the toes also. At the base of the gonys the infra-mandibular region is very thickly feathered, but this dense patch divides abruptly and either passes up on each side and runs along the ear-conch, as in those owls in which this conch is fully developed, or, as in other species, disappears on the rami of the lower jaw. The rest of the chin and throat are very sparsely feathered in most owls, but in others it is fully covered. The lower cervical tract is narrow and is divided on the neck so as to pass down on either side to form the strong sternals. It is also connected with the humerals, and especially with the

* Jour. Linn. Soc., xx, p. 341.

† Jour. of Morph., June, 1889.

triple row of small feathers on the lower edge of the patagium, while all of the upper outer corner of the breast is usually more or less feathered. From the lower end of the sternal tract there runs a strong hook over to the hypopterum, which is itself very evident. There are two rows of primary and three or four of secondary under coverts. The ventral tracts commence on the breast, usually near the furcula, and seem to be fused with the sternals at first, but soon separate from them and run down on either side almost to the anus, becoming very narrow on the belly. *Strix* shows a very peculiar modification of this typical form, in the fusion again of the sternal and ventral tracts at the posterior end of the former. The post-anal tract, comprising the under-tail coverts, is strong and very conspicuous in the larger species. All of the specimens of Striges examined agreed in the following details:

Aftershafts wanting. True down wanting. Oil gland not tufted. Primaries 11, the eleventh very small. Rectrices 12 (except *Micropallas*). Alula feathers 4. Wing aquincubital.

As only nine species, representing eight genera, have been available for study they can not be very satisfactorily arranged in groups pterylographically, but when all the genera are examined such an arrangement may be possible. For the sake of convenience I have, however, divided the eight genera as follows:

I. Head uniformly and thickly feathered above and sometimes below, although the lateral neck spaces reach nearly to the ears and the infra-mandibular region is sometimes sparsely feathered, often showing apteria along the rami of the lower jaw.
  A. Rectrices 10 ..... MICROPALLAS.
  B. Rectrices 12.
    a. Upper cervical tract well forked; ninth, eighth, and seventh primaries longest ..... SPEOTYTO.
    b. Upper cervical tract slightly forked; seventh, sixth, and eighth primaries longest ..... GLAUCIDIUM.

II. Head not uniformly feathered, but usually showing longitudinal rows on the crown, and the infra-mandibular region is very sparsely feathered.
  A. Sternal tract free from ventral at posterior end; outer pair of rectrices shortest.
    a. Linear arrangement of feathers near the center of the crown between the eyes, but on account of their nearness to each other not showing any very definite pattern; lower cervical tract clearly defined on the chin ..... SYRNIUM.
    b. Linear arrangement of feathers on the crown forming a definite pattern between the eyes or else not evident at all; lower cervical tract indistinct on the chin; ninth, eighth, and seventh primaries longest. ASIO.
    c. Linear arrangement of feathers on the sides of the crown, back of the eyes.
      1. Tarsus fully feathered; seventh, sixth, and eighth primaries longest. MEGASCOPS.
      2. Tarsus only feathered in front halfway to the toes .... GYMNOGLAUX
  B. Sternal tract fused with ventral behind as well as in front; middle pair of rectrices shortest.
    a. Ninth, eighth, and tenth primaries longest ..... STRIX.

NOTE.—The above arrangement is not intended to show any affinities between these genera, but simply to set out more prominently some of the differences.

Genus MICROPALLAS.

Unfortunately, I have only had the opportunity to examine one specimen of this very interesting genus of little owls, but Mr. Lucas and Mr. Ridgway have very kindly examined the skins of both *M. whitneyi* and *M. graysoni* in the National Museum, and have thereby confirmed its chief peculiarity, namely, the presence of only ten rectrices. Indeed, the specimen which I examined had only nine, but there is a possibility that one had been lost accidentally. The primaries had been cut, and so their formula can not be given, but there were only 13 secondaries. In the general pterylosis this genus differs from *Asio accipitrinus* (figs. 9 and 10) in the uniform feathering of the head above and below, except the naked space over the eye; in the narrowness and weakness of all the tracts, but especially the femoral; and in the somewhat less complete feathering of the toes, where the feathers are very hair like. The dorsal tract and the posterior end of the cervical were not easy to make out, but seemed to be like *Asio*. In fresh specimens, however, I should expect to find the cervical tract scarcely forked and the dorsal extending forward so as to almost meet it, as in *Glaucidium*.

Specimen examined.

No.	Name.	Collection.	Condition.
1	Micropallas whitneyi	U. S. Nat. Mus	Alcoholic.

Genus SPEOTYTO.

Although this genus shows some modification of the typical Strigine pterylosis, it did not seem necessary to publish a figure, as one has already appeared with a full account of these differences in the Journal of Morphology for June, 1889, by Dr. Shufeldt. All the specimens which I have examined agree with the description there given, although really the width of the tracts is not so especially noteworthy when compared with our other owls as in comparison with the figures of Nitzsch. Indeed, I have not noticed in any of the owls which I have examined the extreme narrowness of the tracts to which Nitzsch called attention, although they may be narrower than those of the hawks and some other birds. The chief peculiarity of *Speotyto* lies in the uniform feathering of the whole head, more complete than in any other owl I have seen. This was especially clear in the young bird from the National Museum, where the sides of the head were more fully clothed than in the adults. The lateral neck spaces are broad and do not reach quite to the ear, as in other owls, but permit, instead, a slight union of the upper and lower cervical tracts on the sides of the head. In all other respects *Speotyto* agrees with *Asio*, except that the tarsus is only feathered to the base of the toes, and that only in front. The eleven primaries rank as follows in length: 9 = 8, 7, 6 = 10, 5, 4, 3, 2, 1, 11.

There are fifteen secondaries and twelve retrices, but of the latter one bird from the National Museum (No. 85253) possessed thirteen.

Specimens examined.

No.	Name.	Collection.	Condition.
1	Speotyto cunicularia hypogæa	U. S. Nat. Mus	Alcoholic.
2	do	do	do.
3	Speotyto cunicularia hypogæa (young)	do	do.
4	Speotyto cunicularia hypogæa	Brownsville	Fresh.
5	do	do	do.
6	do	do	do.

Nitzsch says of *S. cunicularia* that "it has twenty-four remiges, of which ten are on the hand; the first equals the fifth; the second between the fourth and fifth; the third somewhat longer than the fourth." Since he does not mention the *real first* primary, it is necessary to add one to each of these figures in order to get the formula as he meant it. Reversing the notation, it then becomes 8, 7, 9, 6=10, 5, 4, 3, 2, 1, 11, which agrees substantially with what I have given. Although Nitzsch allows the genus only fourteen secondaries, both Dr Shufeldt and I found fifteen.

Genus GLAUCIDIUM.

The pterylosis of this genus is very similar to that of *Micropallas* and *Speotyto*, but the infra-mandibular region is not at all thickly feathered and there are distinct apteria along the rami of the lower jaw. The upper cervical tract is broader than usual and posteriorly divides so very slightly that the fork is not clearly defined at all, while the dorsal tract extends farther forward than in *Asio*, although it does not quite reach the end of the cervical. The humeral tracts are not very broad, being narrower than the upper cervical. The femoral tract is well developed and the tarsus is feathered only as far as the somewhat hairy toes. Beneath *Glaucidium* agrees closely with *Asio*, although the ventral tracts are not quite so clearly marked on the breast. The formula for the primaries is as follows: 7, 6, 8, 5, 4=9, 3, 2, 1, 10, 11. Two of the specimens examined had fourteen and the other two fifteen, secondaries, while there are, as usual, twelve rectrices.

Specimens examined.

No.	Name.	Collection.	Condition.
1	Glaucidium phalænoides	Brownsville, Tex	Fresh.
2	do	do	do.
3	do	do	do.
4	do	do	do.

Genus SYRNIUM.

The only specimen of this genus which I have examined agrees very well in the general pterylosis of the body with *Asio accipitrinus*, but dif-

fers on the head in a few details. The lower cervical tract is clearly defined on the chin instead of being indistinctly scattered, while on the crown the longitudinal rows are so close together and so similar that the general effect is like the uniform feathering of *Speotyto*. The feet are fully feathered to the base of the toes and the latter are more or less feathered above. The wings had been clipped but there were apparently sixteen secondaries.

Specimen examined.

No.	Name.	Collection.	Condition.
1	Syrnium nebulosum.....	U. S. Nat. Mus	Alcoholic.

Genus ASIO.

This genus seems to me to show, best of all the owls I have examined, the typical Strigine pterylosis, and this is especially true of *A. accipitrinus*. The dense feathering of the anterior part of the head; the apterium above the eye; the four distinct longitudinal rows on the

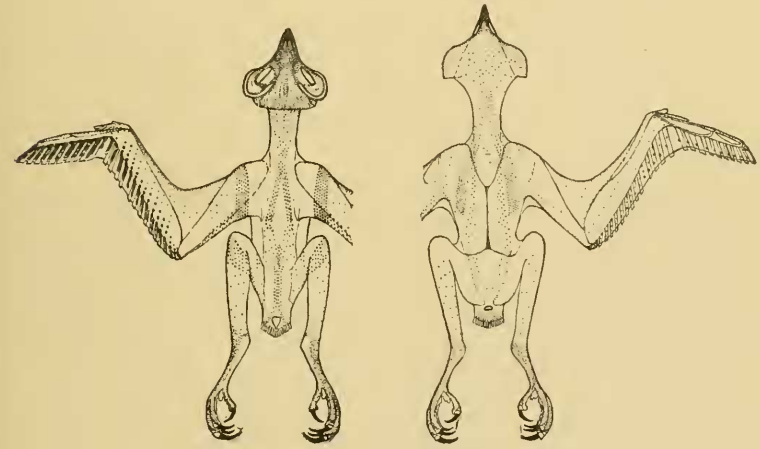

Fig. 9. Fig. 10.

PTERYLOSIS OF ASIO ACCIPITRINUS.

crown, a pair on each side; the broad upper cervical tract rapidly narrowing and deeply forked; the strong humeral tract and parapterum on each wing; the rather weak dorsal tract indistinct at first, but clearly defined posteriorly and forking to include the naked oil gland; the strong femorals with numerous scattered feathers between them and the dorsal; the feathering of the feet almost to the claws; the very sparsely feathered infra-mandibular space; the deeply forked lower cervical tract; the very evident contour feathers on the upper outer

part of the breast, and chiefly the complete separation on the breast of the sternal and ventral tracts, all make up the typical pterylosis of the owls and are clearly shown in figs. 9 and 10. *Asio wilsonianus* does not show these points as well, or at least the specimens which I was able to obtain did not show them, but as they were not in very good condition it is possible that perfect material will show more complete agreement with *Asio accipitrinus*. The species of *wilsonianus* examined did not show clearly the longitudinal arrangement of feathers on the crown, although the head was not uniformly feathered as in *Speotyto;* the femoral tract was no longer a true femoral, but scarcely reached the femur at all, being confined to the back of the tibia (this may be easily understood by imagining the femoral tract in fig. 10 to be moved down on the tibia one-eighth of an inch nearer the tarsus); on the front of the tibia the feathering was so very dense that there was a very distinct tract there. The two species agreed in possession of *fifteen* secondaries and in the following formula for the primaries: 9, 8, 7, 10=6, 5, 4, 3, 2, 1, 11.

Specimens examined.

No.	Name.	Collection.	Condition.
1	Asio wilsonianus	Amherst, Mass	Fresh.
2	do	U. S. Nat. Mus	Alcoholic.
3	Asio accipitrinus	Brownsville, Tex	Fresh.
4	do	do	do.
5	do	do	do.
6	do	do	do.
7	do	do	do.

Nitzsch says of *Strix brachyotus:* "Twenty-four remiges, the second the longest, the first somewhat shorter than the third." Making the same addition and reversion as we found necessary under *Speotyto*, this formula becomes 9, 8, 10, 7, 6, 5, 4, 3, 2, 1, 11, which is almost the same as that I have given. He only credits the genus with fourteen secondaries, while I have always found one more.

Genus MEGASCOPS.

Except for the peculiar difference in the arrangement of the longitudinal rows on the head, the pterylosis of this genus is very much like that of *Asio*. This difference is very well shown in the plates and may be briefly characterized thus: In *Asio* the longitudinal rows are central, while in *Megascops* they are lateral. On the infra-mandibular space the feathers are more numerous in the screech owls, but other distinctions are not obvious. There are fourteen secondaries, and the eleven primaries rank as follows: 7=6, 8, 5, 9, 4, 3, 2, 10=1, 11. The feet were more heavily clothed in feathers, though the same surface was

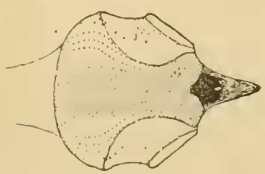

Fig. 11.

HEAD OF MEGASCOPS ASIO.

Showing arrangement of longitudinal rows.

covered, in the specimen from New York State than in *kennicotti*, and in the latter more than in *mccallii*.

Specimens examined.

No.	Name.	Collection.	Condition.
1	Megascops asio	Pittsburg, Pa	Fresh.
2	....do	Rochester, N. Y	do.
3	Megascops asio mccalli	Brownsville, Tex	do.
4	Megascops asio kennicotti	U. S. Nat. Mus	Alcoholic.

Nitzsch says of *Scops asio:* "Twenty-two remiges * * * the fourth the longest, the third equal to the sixth, the second to the seventh, and the first scarcely to the ninth." This gives the formula 7,6,8=5, 9=4,3,2,10,1,11, which is about what I have given. He only allows twelve secondaries, while I have always found fourteen.

Genus GYMNOGLAUX.

Among the other owls from the National Museum, there was a representative of this genus from Puerto Rico, but its specific identity was not known. It agreed in nearly all particulars with *Megascops*, the only important difference being in the feathering of the feet. The longitudinal rows on the head were arranged as in *Megascops*, although they were not quite so clearly defined. The tibia was heavily feathered in front, but the tarsus was only clothed about half-way down and was bare on the sides and behind, so that it was more extensively denuded than in any other owl examined. The primaries had unfortunately been cut, so that their formula can not be given, but there seemed to be only thirteen secondaries, a small number for an owl.

Specimen examined.

No.	Name.	Collection.	Condition.
1	Gymnoglaux sp. ?	U. S. Nat. Mus	Alcoholic.

Genus STRIX.

This genus shows a greater variation from the normal owl-type than any other of which I know and would deserve a figure if it had not already been so well figured by Nitzsch. It differs from *Asio* in the following particulars: The head is more uniformly feathered above and shows no signs of longitudinal rows, but the infra-mandibular region is scarcely feathered at all, except for the very narrow lower cervical tract, which begins at the base of the gonys and extends nearly to the furcula before forking widely. It is, however, slightly divided for some distance before it actually forks, so that the upper part of each branch is abruptly

wider than the lower, although there is no true inner branch given off. The upper cervical tract is very narrow, while the humerals are narrower than in any other genus and the parapterum is weak. The femorals are strong, but very diffuse, and are scattered over most of the femur. The feet are not feathered quite to the toes, but the latter are very hairy. The sternal tract is fused with the ventral, not only at its origin near the furcula, but also at the other end of the breast, so that the tracts are really one; very broad on the sternum, and containing a longitudinal apterium, and becoming abruptly narrow on the belly. The hypopterum is very strongly marked, and the hook connecting it with the sternal tract is composed of larger feathers, and they are much more numerous than in the other owls. Indeed, the whole breast is much more thickly feathered than in *Asio*. Another remarkable peculiarity is the formula for the comparative lengths of the *rectrices*. In all the other owls the middle pair of tail-feathers is the longest and the external pair shortest, so that the formula is 1, 2, 3, 4, 5, 6. In *Strix*, however, this is exactly reversed, the outer pair being the longest and the formula reading 6, 5, 4, 3, 2, 1. There are fifteen secondaries and the primaries rank as follows: 9, 8, 10, 7, 6, 5, 4, 3, 2, 1, 11.

Specimens examined.

No.	Name.	Collection.	Condition.
1	Strix pratincola	Brownsville, Tex	Fresh.
2	do	do	do.

Nitzsch says of *Hybris flammea:* "Twenty-four remiges, the three first about equally long, but the second is really the longest." This formula is the same as what I have just given. There are, however, fifteen secondaries, instead of fourteen, as Nitzsch says.

COMPARISON OF THE TWO GROUPS.

Before entering on a detailed comparison of the two groups which we have been examining, it will set some of the facts more clearly before us if we arrange them in tabular form.

Comparison of the groups.

Group.	Number of primaries.	Number of feathers in the alula.	Aftershaft.	Condition of oil-gland.	True down.	Condition of wing.
Caprimulgi	10	3	Present	Bare	Wanting	Aquincubital.
Striges	11	4	Wanting	do	do	do.

Comparison of the genera.

Genus.	Pterylosis of the crown.	Rectal bristles.	Primary formula.
Phalænoptilus	Longitudinal rows	Present	
Antrostomus	do	do	8=9, 7=10, 6, 5, 4, 3, 2, 1.
Nyctidromus	do	do	8, 9, 7, 10, 6, 5, 4, 3, 2, 1.
Chordeiles	do	Wanting	10, 9, 8, 7, 6, 5, 4, 3, 2, 1.
Micropallas	Uniform	do	
Speotyto	do	do	9=8, 7, 6=10, 5, 4, 3, 2, 1, 11.
Glaucidium	do	do	7, 6, 8, 5, 4, 9, 3, 2, 1, 10, 11.
Asio	Longitudinal rows	do	9, 8, 7, 10=6, 5, 4, 3, 2, 1, 11.
Syrnium	do	do	
Megascops	do	do	7, 6, 8, 5, 9, 4, 3, 2, 10, 1, 11.
Gymnoglaux	do	do	
Strix	Uniform	do	9, 8, 10, 7, 6, 5, 4, 3, 2, 1, 11.

Genus.	Number of secondaries.	Pterylosis of the feet.	Number of rectrices.	Formula for rectrices.
Phalænoptilus	12	Bare	10	1, 2, 3, 4, 5.
Antrostomus	12	Tarsus feathered halfway down in front	10	1, 2, 3, 4, 5.
Nyctidromus	12	Bare	10	1, 2, 3, 4, 5.
Chordeiles	13	Tarsus feathered halfway down in front	10	5, 4, 3, 2, 1.
Micropallas	13	Fully feathered	10	1, 2, 3, 4, 5.
Speotyto	15	Feathered to base of toes	12	1, 2, 3, 4, 5, 6.
Glaucidium	14 or 15	do	12	1, 2, 3, 4, 5, 6.
Asio	15	Fully feathered	12	1, 2, 3, 4, 5, 6.
Syrnium	16	Almost fully feathered	12	1, 2, 3, 4, 5, 6.
Megascops	14	Fully feathered	12	1, 2, 3, 4, 5, 6.
Gymnoglaux	13	Tarsus feathered halfway down in front	12	1, 2, 3, 4, 5, 6.
Strix	15	Feathered to toes	12	6, 5, 4, 3, 2, 1.

Having thus set the more important facts before us in a condensed and therefore convenient form, let us see what inferences, if any, can be drawn from them. In order to estimate correctly the value of likenesses and the weight of differences, one must first consider the relative importance of the different pterylographical characters in any two groups. We may safely assert that the most importance attaches to the fundamental plan of the pterylosis, while slight variations carry little weight. This is to be inferred from the uniform pterylosis of clearly defined groups such as the Grouse or even the Passeres. Next to this I should rank the condition of the wing, whether aquincubital or not, and the number of rows of coverts and then the condition of the oil-gland tuft, aftershaft, and down. The number of rectrices, remiges, and feathers in the alula are much more variable and depend to some extent perhaps on the size of the bird, but of course agreement in these details would carry more weight than differences. Less valuable would be the denudation of the tarsus and tibia, which is more or less dependent on the habits of each species, while the least important of all characters is the presence or absence of peculiar feathers or crests, because these often differ even in the two sexes of the same species. Estimating the value of the characters in this way, let us now examine, under the following four heads, the comparative pterylography of the two groups before us: (1) fundamental plan of pterylosis, together with its variation in detail; (2) arrangement of the feathers of the wing; (3) aftershafts, oil gland, and down; (4) tail.

Fundamental plan and variation in detail.—In regard to the fundamental plan of the pterylosis, it needs only a glance at the figures to show us that while dorsally the two groups are very similar, there is ventrally at least one important difference. On the head the feathering is much more dense and uniform in Striges than in Caprimulgi, but there are nevertheless signs in the former group of a tendency towards a less uniform covering, as witness the longitudinal rows of *Asio* and *Megascops*. Furthermore, in *Chordeiles*, there is a much more uniform feathering of the infra-mandibular region than in any owl except possibly *Spcotyto*. There is no constant difference between the two groups in the upper and lower cervical tracts which are always narrow and clearly forked. The dorsal tract is practically the same in both, varying indeed in the different genera as to its extent and its union with the forks of the upper cervical. The strong humerals with an evident parapterum are also common to the two groups and the peculiarly placed femoral tract is likewise characteristic of both, which is the more remarkable as the tibia is always much more heavily feathered in Striges. As a rule, too, the owls have the feet much more fully clothed, but as much of the tarsus is bare in *Gymnoglaux* as in *Antrostomus* so that this slight difference is by no means constant. On the ventral surface the two groups agree in several minor details such as a strong hypopterum and hook, connecting with the sternal tract, and the numerous scattered feathers on the upper outer corner of the breast and on the shoulder, including a connection between the lower cervical and the humeral tracts. But it is on the breast that we find the first real difference in the fundamental plan, and this demands a careful examination. In the Caprimulgi, the lower cervical after forking continues on each side as a single tract, forming on the breast a broad and strong sternal, and on the belly, after narrowing abruptly, the much weaker ventral tract. In the Striges on the other hand, the lower cervical, after forking, forms on each side of the breast the well-marked sternal tracts, but does not continue down on the belly to form the ventrals. These are, on the contrary, in the typical Strigine pterylosis, entirely separate from the other tracts at least as far up as the furcula and owing to their weakness at that point their union with the sternals is often very indistinct. It will be at once seen that this difference is really important, but when we consider the condition of these tracts in *Strix*, we find an arrangement that is really intermediate between the two groups, and this gives us a hint as to how the Caprimulgine form may have been derived from such an arrangement as occurs at present in the owls. In *Strix*, as has already been pointed out, not only do the ventral and sternal tracts fuse clearly near the furcula, but owing to the slight outward curve of the former and a more abrupt inward curve of the latter, the two unite at the posterior extremity of the sternals so as to form in reality one broad tract on the breast, containing a longitudinal apterium. It

will be easily seen that should this fusion increase at each end and continue until the apterium had disappeared, we would arrive at the Caprimulgine condition. May it not be true that in this way the single tract of the Caprimulgi has been formed? At any rate there is nothing inherently improbable in the idea. If this be granted the conclusion is inevitable that the fundamental plan of the pterylosis was originally the same in both groups, and since in those minor points in which they differ (such as the longitudinal rows on the head in the Caprimulgi and the feathering of the tarsus in the Striges) there are numerous intergradations, there is certainly reason to admit the possibility of some relationship. It may be mentioned here that *Strix* shows another peculiarity which is not unlike one of the features of *Chordeiles*. It will be remembered that the lower cervical fork of the latter genus shows a prominent inner branch and although this is not found in any owl, yet the peculiar formation of the tract in *Strix* gives us a hint as to its possible origin. The above hypotheses in regard to the origin of the single sternal-ventral tract in the Caprimulgi and the inner cervical tooth in *Chordeiles* seem to indicate greater specialization on the part of this group and it is worth while to bear this in mind as we consider the other characters to be compared.

Arrangement of the feathers of the wing.—Since the wing is one of the most characteristic organs of a bird, and since variations in the arrangement of its feathers are almost endless even within the limits of well-defined groups, similarities in these points must carry considerable weight, especially when these likenesses are in such details as the comparative length of the primaries. If we compare the wing of an owl with that of one of our goatsuckers, we find substantial agreement in several points, but some apparently important differences in others. Both agree in being aquincubital, a character which seems to be of the greatest importance. They agree further in the number of rows and distribution of the coverts and even fairly well in the comparative lengths of the primaries. Thus among the Caprimulgi, the eighth and ninth are about equal and are longest; then follow the seventh and tenth (about equal), and the sixth, very little shorter, and then 5, 4, 3, 2, 1. *Chordeiles* (according to Coues) has the tenth equal to the ninth and the rest in regular succession. Among the owls examined there are three groups; *Asio* and *Spectyto* agreeing very closely with the whip-poor-will as above given, the eighth and ninth being about equal, seventh next, sixth and tenth (equal), and the rest in regular order; *Strix* differing from these and approaching *Chordeiles* in the greater length of the tenth primary, which is longer than the seventh and almost equals the ninth; *Glaucidium* and *Megascops* showing a very different arrangement with the seventh longest and the tenth about equal to the first. Striges, however, possess the eleventh primary in a rudimentary condition, while it has completely disappeared in the Caprimulgi. The latter have only three feathers in the alula,

while the owls have four. The number of secondaries varies in the different genera, but it is almost always greater in the owls. It will be noticed that these differences are all numerical and that the smaller number is always the characteristic of the Caprimulgi. It is well known that in the evolution of birds there has been a distinct tendency towards a reduction of the number of remiges and this tendency has been very marked in the specialization of many groups of small land birds. This reduction takes place not only at the upper or inner end of the forearm, thus decreasing the number of secondaries, but also at the outer end of the hand, thus decreasing the number of primaries. The former is much the more common and extensive method, so that the number of secondaries may vary between six and forty; while the latter is limited to one or two feathers only, the number of primaries at least in Carinate birds, varying between ten and twelve.* We thus see that in the structure of the wing, the Caprimulgi show a greater specialization than the Striges, although the arrangement of the coverts, the absence of the fifth secondary, and the comparative lengths of the primaries would seem to indicate that the original plan of the wing was the same in both groups. This is in line with the conclusion to which our examination of the general pterylosis had brought us and the consideration of the remaining characters may throw still more light on the subject.

The presence of aftershafts, oil gland, and down.—In the general structure of the plumage there is a superficial resemblance between the owls and goatsuckers, but a careful examination does not altogether bear this out. The greatest difference lies in the presence of an aftershaft on the feathers of the Caprimulgi which is entirely lacking in Striges. Although stronger in *Nyctidromus* than *Chordeiles*, it is, even in that genus, very weak, although I have always found it present. In the owls, however, it is uniformly absent and I have found no trace of it in any of the specimens which I have examined. This difference can not, therefore, be easily explained away, at least not until we know more of the origin and function of the aftershaft and are better acquainted with the pterylography of all the genera. I have already spoken of the peculiar length of the calamus in the large wing and tail feathers of the Caprimulgi, but I did not find the same structure clearly shown among the owls, except in *Glaucidium*, where it was as evident as in *Nyctidromus*. Down feathers are very rare in both groups, if present at all, and I found no trace of an oil-gland tuft in either, although Nitzsch speaks of finding a trace of it in *Strix*.

Number and length of feathers in the tail.—What has been said above in regard to the reduction of the number of remiges in birds is also true of the rectrices, although the evidence is less satisfactory. However, it will hardly be disputed that the presence of ten rectrices in the Caprimulgi indicates greater modification than the presence of twelve

* See Dr. Gadow's interesting article in Proc. Zool. Soc., 1888, p. 655.

in the owls. This difference in number might have been something of a difficulty in showing any connection between the two groups were it not for the interesting discovery that *Micropallas* possesses only ten, a fact which seems to have previously escaped notice. Another thing of interest in regard to the tail is that while in both Striges and Caprimulgi it is the rule for the middle pair of rectrices to be longest, there is an exception in each group; among the former *Strix*, and in the latter, *Chordeiles*, has the outer pair longest.

CONCLUSIONS.

Having thus compared in detail the pterylographical characters of both Caprimulgi and Striges, as far as the material at hand would allow, I may justly be permitted to draw a few inferences from the facts before me. It can hardly be denied that these facts indicate a certain degree of affinity, and although to me this relationship seems quite close, of course it is well understood that conclusions based on one set of facts will often be overturned by another set and are, therefore, unreliable. Judging from the wings and tail, the united sternal and ventral tracts, and the striking longitudinal arrangement of the feathers on the crown, there can be little doubt that the Caprimulgi are the more decidedly modified of the two groups. In each one of these particulars, moreover, there are owls almost as fully modified, yet they do not combine them as do all of the Caprimulgi. Thus, *Micropallas* has only ten rectrices, but the head is uniformly feathered and the ventral tract is distinct, while *Strix* shows a partial union of the sternal and ventral tracts, but has twelve rectrices and a closely feathered crown. We may thus reasonably conclude that the common ancestors of the two groups were rapacious birds much more like owls than goatsuckers and probably more or less nocturnal in their habits. They had a well-feathered head, a widely forked upper cervical tract, separate sternal and ventral tracts, a peculiarly situated femoral tract, twelve rectrices, of which the middle pair were longest, and twenty-six or more remiges, of which eleven were on the hand. The plumage probably possessed an aftershaft and the oil gland was bare, while the tarsus may have been feathered. From this extremely hypothetical stem, there soon arose birds more crepuscular than nocturnal and insectivorous rather than carnivorous. These were the immediate ancestors, of the Caprimulgi and soon lost the first primary, one pair of rectrices, and several secondaries. In them also the ventral and sternal tracts fused and the feathers of the head condensed into longitudinal rows, while the feathers of the tarsus began to disappear. Thus the general Caprimulgine pterylosis arose by what will at once be seen as a process of condensation, possibly due to the need of greater lightness and speed for the capture of their insect prey. *Phalænoptilus* shows the most perfect development of this Caprimulgine form and so is the most modern descendent of these hypothetical ancestors. *Chordeiles*

seems to have branched off from the Caprimulgine form very early and probably by becoming diurnal to a greater degree. Thus having little need of sensitive rictal bristles, it lost them, while the wing and tail were also modified. Among the owls the variation from the supposed ancestral form has been more spasmodic and the direct progress much less, but the pterylography of even the American forms is too little known to draw any satisfactory conclusions. It is certainly a very curious fact that *Strix* shows some variations which are completely parallel to those of *Chordeiles;* thus, the outer pair of tail feathers is the longest, the tenth primary almost equals the ninth, the peculiar forking of the lower cervical tract gives a hint of the origin of the inner branch of *Chordeiles*, and, finally, the partial fusion of the sternal and ventral tracts is decidedly Caprimulgine. Whether this indicates a nearer approach to that hypothetical, lost, parent form is, to say the least, doubtful. More probably *Strix* has varied from the Strigine stem in the same way, though to a greater degree, perhaps, than *Chordeiles* has from the Caprimulgine.

The conclusion, then, to which this study of their pterylography has brought me is that the Caprimulgi are related to Striges, and not very distantly either—probably a branch from the early part of the Strigine stem. Dr. Sharpe, in his address at Budapest on "Recent Attempts to Classify Birds," says that the idea that Caprimulgi and Striges are nearly allied "is now scouted," but he admits that the nearest approach to the latter is in *Steatornis*. Garrod, in his very interesting account of the latter genus,* concludes that it resembles Striges much more than Caprimulgi, while Parker† considers its resemblance to either group as being purely analogous, and so forming no connecting link between the two. The weight of argument perhaps, of authorities certainly, is thus directly opposed to the conclusions to which my observations had led me. It must be, therefore, as above stated, that a conclusion based on one set of facts only is eminently unreliable and should be set aside if the other characters are all against it. However this may be, I can only say that a comparative study of the pterylography of the two groups as represented in North America most certainly shows some surprising similarities. Perhaps, however, it is only an extraordinary case of what may be called "analogous variation."

*Proc. Zool. Soc., London, 1873, p. 526.

†Opp. cit., 1889, p. 161.